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(contd)

ii) depositing a second amount of metal on said seed layer at a substrate temperature and power that are sufficient to (i) inhibit formation of filamentous metal phases having a resistivity greater than that of said metal, and (ii) provide a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0; and

iii) depositing a third amount of metal on said second amount of metal.

22. (Amended) A method of forming a layer of aluminum-containing metal on a substrate, comprising:

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i) depositing a first amount of a metal comprising aluminum on a seed layer of the metal, said seed layer being sufficient to cover a substrate surface comprising titanium, at a substrate power sufficient to inhibit formation of a phase of $TiAl_3$ having a resistivity greater than that of said metal said seed layer of metal being deposited at a substrate temperature of from 220 to 300°C; and

ii) depositing a second amount of metal on said first amount of metal.

24. (Amended) A method of forming a layer of aluminum-containing metal on a substrate, comprising:

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i) depositing a first amount of a metal comprising aluminum on a seed layer of the metal, said seed layer being sufficient to cover a substrate surface, at a substrate power sufficient to inhibit formation of a phase containing said metal having a resistivity greater than that of said metal and at a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0 said seed layer of metal being deposited at a substrate temperature of from 220 to 300°C; and

ii) depositing a second amount of said metal on said first amount of metal.

SUPPORT FOR THE AMENDMENT

Support for the amendment to Claim 1 is found on page 12, lines 2-5, of the specification. Support for the amendment to Claims 1, 22 and 24 is found on page 12, line 18, of the specification. No new matter would be added to this application by entry of this amendment.

Upon entry of this amendment, Claims 1-24 will remain active in this application.

RECONSIDERATION FOR RECONSIDERATION

The present invention is directed to a method of forming a layer of metal on a substrate.

During the formation of semiconductor devices, metallization layers are generally formed in trenches and openings to form interconnects and vias. Formation of such metal layers can sometimes be complicated by difficulties with the conductivity of the metallization layers and accordingly efficient methods for forming such metallization layers of good conductivity are sought.

The present invention addresses the problem by providing a method of forming a layer of metal on the substrate which comprises depositing a seed layer of metal on a surface of Ti at a substrate temperature of from 220 to 300°C followed by depositing a second amount of metal under temperature and power conditions sufficient to inhibit the formation of filamentous metal phases having a resistivity greater than that of said metal and providing a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0, followed by depositing a third amount of metal. Applicants discovered that a process in which a seed layer of metal is formed on a surface of Ti at a substrate temperature of from 220-300°C is effective in a method of forming a layer of

metal on a substrate. More specifically, Applicants have discovered that such a seed layer allows for the deposition of metal on said seed layer at a substrate temperature and power that are sufficient to (i) inhibit formation of filamentous metal phases having a resistivity greater than that of said metal, and (ii) provide a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0; Such a method is nowhere disclosed or suggested in the prior art of record.

The rejections of Claims 1-5 and 7-24 under 35 U.S.C. § 102(e) and of Claim 6 under 35 U.S.C. § 103(a) over Xu U.S. 6,217,721 is respectfully traversed.

Xu fails to disclose or suggest a method in which a high aspect opening is filled with a metal in which a Ti liner layer is used, and the seed layer is formed at temperature of from 220-300°C.

Xu describes a method of filling metal in which an opening is provided with a multilayer liner layer comprising a refractory metal of Ti, a second sublayer of a refractory compound of a refractory nitride such as TiN and a third sublayer which includes an upper portion of a refractory metal such as Ti and may be graded from TiN in its lower portion (column 8, lines 13-21). A metal layer is then formed by PVD in a two-step process of a first cold deposition and then a hot deposition (column 8, lines 24-27). Cold deposition is illustrated at column 20, line 11, as Al sputtering at a substrate temperature of only 130°C or lower to form a seed layer. The reference teaches the preferred cold deposition temperature to be 200°C or below as the dewetting temperature is 250°C (column 24, lines 58-60).

In contrast, the present invention is directed to a process in which a seed layer of metal, which may be Al, is formed on a first substrate surface which is Ti, at a substrate temperature of from 220-300°C. Applicants note that the claims have been amended to recite deposition onto a surface which is Ti, at a substrate temperature of from 220-300°C.

Applicants respectfully submit that there is no suggestion in the cited reference to use a substrate surface (e.g., a liner layer) which is Ti at a temperature of from 220-300°C. Quite to the contrary, the reference teaches cold deposition at a temperature of only 130°C (column 20, lines 10-11) and describes the preferred cold deposition temperature to be 200°C or below as dewetting temperature is 250°C (column 24, lines 58-60). As such, the reference clearly teaches a preference for a cold deposition temperature of 200°C or below, which is not suggestive of a temperature of 220-300°C. Moreover, by illustrating a temperature of 130°C, there is no motivation to exceed the described range of 200° or below as the reference clearly illustrates a preference for a temperature even lower than 200°C.

However, while it may ordinarily be the case that the determination of optimum values for the parameters of a prior art process would be at least *prima facie* obvious, that conclusion depends upon what the prior art discloses with respect to those parameters. Where, as here, the prior art disclosure suggests the outer limits of the range of suitable values, and that the optimum resides within that range, and where there are indications elsewhere that in fact the optimum should be sought within that range, the determination of optimum values outside that range may not be obvious. We think it is not on the facts of this case (*In re Sebek*, 175 USPQ 93, 95 (CCPA 1972)).

As such, the claimed temperature range of 220-300°C is clearly not disclosed or suggested by the cited reference and accordingly withdrawal of the rejections under 35 U.S.C. § 102 and 103 is respectfully requested.

The rejection of Claims 1-21 and 24 under the judicially created doctrine of obviousness-type double patenting over Claims 1-24 of U.S. 6,140,228 and of Claims 22-23 under the judicially created doctrine of obviousness-type double patenting over Claims 1-24 of U.S. 6,140,228 in view of Xu are respectfully traversed.

U.S. '228 does not claim deposition onto a liner layer which is Ti nor does it claim deposition of a **seed layer** at a temperature of from 220-300°C. As such, the claimed invention is clearly not obvious under the judicially created doctrine of obviousness-type double patenting

as the claim limitations of a Ti liner layer and a seed layer deposition temperature of from 220-300°C are not disclosed or suggested in the reference. Accordingly, withdrawal of the rejection under the judicially created doctrine of obviousness-type double patenting is respectfully requested.

As noted by the Examiner, Applicants have corrected the typographical error in Claim 24. With regard to the title, the Examiner is respectfully requested to suggest a more informative title as appropriate.

Applicants submit this application is now in condition for allowance and early notification of such action is earnestly solicited.

Respectfully submitted,

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A handwritten signature in black ink, appearing to read "Richard L. Chinn", with a checkmark to the right.

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